

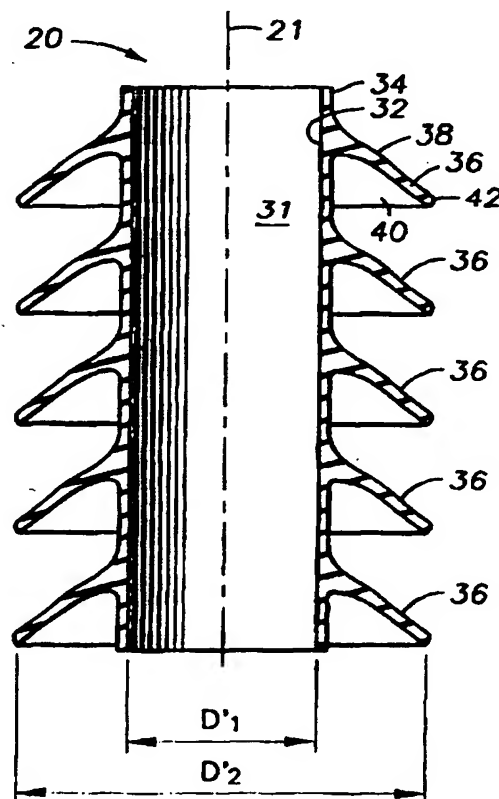


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(54) Title: POLYMERIC WEATHERSHED SURGE ARRESTER AND METHOD**(57) Abstract**

An elastomeric surge arrester housing (20) includes a sleeve having a tubular core (30) and radiating sheds (36). The sleeve is molded in a first configuration and, when the core (30) is radially stretched, assumes a second configuration in which the sheds (36) assume a downwardly extending configuration. The sheds (36), in the second configuration, include an upper surface having a generally frustoconical shape. The housing (20) may be made using conventional molding techniques, but requires substantially less material if the housing (20) were molded directly into the second configuration.



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POLYMERIC WEATHERSHED SURGE ARRESTER AND METHOD**BACKGROUND OF THE INVENTION**

5 The present invention relates generally to electrical power distribution equipment. More particularly, the invention relates to surge arresters. Still more particularly, the invention relates to surge arresters employing polymeric weathersheds.

 Under normal operating conditions, electrical transmission and distribution equipment is subject to voltages within a relatively narrow range. Due to lightning strikes, switching surges
10 or other system disturbances, portions of the electrical network may experience momentary or transient voltage levels that greatly exceed the levels experienced by the equipment during normal operating conditions. Left unprotected, critical and costly equipment such as transformers, switching apparatus, computer equipment, and electrical machinery may be damaged or destroyed by such over-voltages and the resultant current surges. Accordingly, it is
15 routine practice to protect such apparatus from dangerous over-voltages through the use of surge arresters.

 A surge arrester is a protective device that is commonly connected in parallel with a comparatively expensive piece of electrical equipment so as to shunt or divert the over-voltage-induced current surges safely around the equipment, thereby protecting the equipment and its
20 internal circuitry from damage. When caused to operate, a surge arrester forms a current path to ground having a very low impedance relative to the impedance of the equipment that it is protecting. In this way, current surges which would otherwise be conducted through the equipment are instead diverted through the arrester to ground.

 Conventional surge arresters typically include an elongate outer housing made of an electrically insulating material, a pair of electrical terminals at opposite ends of the housing for
25 connecting the arrester between a line-potential conductor and ground, and an array of electrical components in the housing that form a series path between the terminals. These components typically include a stack of voltage-dependent, nonlinear resistive elements. These nonlinear resistors or "varistors" are characterized by having a relatively high resistance at the normal
30 steady-state voltage and a much lower resistance when the arrester is subjected to transient over-voltages. Depending on the type of arrester, it may also include one or more electrodes, heat sinks or spark gap assemblies housed within the insulative housing and electrically in series with the varistors.

housing surface by rain, wind and other conditions. These contaminants, over time, may build up to such a degree that they form a path for current. Such buildup effectively reduces the distance between energized or line-potential components and ground. In this manner, the surface resistivity of the arrester housing will decrease to a point where flashover may occur and a short circuit result. Accordingly, weathersheds have traditionally been included on an arrester housing to extend or lengthen the housing surface and increase the effective distance between the energized arrester terminal and ground. Additionally, weathersheds have been designed to enhance the ability of the arrester to resist or to minimize the degree to which dust and environmental contaminants may build up on the housing's outer surface. Such designs have included varying the radii of adjacent sheds, using particularly designed materials that resist the effects of contamination, and by varying the number and size of the sheds on the housing.

Surge arrester housings made of porcelain were once the industry standard. Unfortunately, such arrester housings were fragile and frequently were the subject of vandalism. Additionally, the porcelain housing was heavy, requiring a substantial support means to mount the arrester. Furthermore, when a porcelain housed arrester failed, it was not uncommon for the housing to explode, sending porcelain fragments at high velocities in all directions. Such failures presented the obvious potential for danger to personnel and damage to equipment.

Presently, at least in distribution class surge arresters, a polymeric housing has become a standard feature. A polymeric housing is less expensive to manufacture, is nonfragmenting and is less susceptible to damage during shipment, installation and use compared to prior art porcelain housings. Additionally, a polymeric housing is substantially lighter, allowing simpler and less costly installation.

The polymeric arrester housing is typically molded of silicone rubber or another elastomeric material. The housing includes a central core and radiating sheds or skirts which are molded integrally with the central core. The central core includes an internal bore or chamber that is substantially the same diameter as the varistors and other arrester components to be housed therein. Where a particular shape or orientation of the sheds is desired, the mold for the housing is manufactured so as to provide that desired configuration.

Present molding techniques effectively limit the configuration and arrangement of sheds on a polymeric arrester housing. Further, because of limitations in the molding process, manufacturing housings with certain weathershed orientations is costly and difficult. Also, the present methods of obtaining a good bond between the inside surface of the housing and the internal components is expensive and generates a substantial amount of scrap material.

Accordingly, there remains a need in the art for a polymeric arrester housing having an enhanced weathershed design that will resist buildup of environmental pollutants and, at the same

time, is relatively simple to manufacture using conventional molding techniques. It would further be advantageous if the housing provided a superior bond between the inside surface of the housing and the internal electrical components. Given the present cost of silicone rubber and other elastomeric materials known to be employed in arrester housings, it would be further advantageous if the weathershed could be manufactured using less material than presently employed for similar housings.

SUMMARY OF THE INVENTION

The present invention includes an elastomeric housing for a surge arrester that includes a deformable shedded sleeve with a tubular core having central bore and a plurality of axially-spaced sheds radially extending from the core. The sleeve has a first configuration when the core is unstretched, and a second configuration when the core is stretched. When the core is stretched radially, the sheds assume a new configuration in which the upper surface is generally frustoconical and in which the ends of the sheds move axially from their initial configuration; however, the ends of the sheds remain at the same predetermined radial position in both the first and second configuration. It is preferred that the sheds extend downwardly from the core at an angle within the range of approximately 10 to 60°, and more preferably 10 to 45°, when the sleeve is in the stretched configuration.

The elastomeric housing is preferably made of a silicon rubber and is molded in the first, unstretched configuration. In that configuration, the upper surface of the shed joins the core portion in a shoulder having a radius of curvature of R_1 and the lower surface of the shed joins the core portion in a lower shoulder having a radius of curvature R_2 , R_1 being greater than R_2 . Additionally, in the first configuration, the upper surface of the shed includes a first transition point where two frustoconical surface segments are joined. Also, in the first configuration, the lower surface of the shed includes a second transition point at the intersection of a pair of frustoconical surface segments. The frustoconical surface segments on the upper surface taper downwardly while the frustoconical surface segments on the lower surface taper upwardly. The sheds are configured such that the second transition point is closer to the axis of the housing than the first transition point. In addition, the downward angle on the top side is preferably greater than or equal to the upward angle on the bottom side.

The present invention permits an elastomeric arrester housing to be created with appropriately configured, downwardly extending sheds, but allows the housing to be molded with sheds that are substantially perpendicular to the axis of the housing. This provides significant manufacturing advantages in that it is a much simpler process to mold an elastomeric housing having sheds that extend substantially perpendicular to the housing axis. Additionally, the invention permits an elastomeric housing that may be stretched or deformed so as to have a particularly

advantageous configuration of downwardly extending sheds where the housing is manufactured using significantly less volume of elastomeric material than if the housing were molded into the ultimately-desired configuration using conventional techniques. These and various other characteristics and advantages of the present invention will be readily apparent to those skilled in the art upon reading the following detailed description in referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

For an introduction to the detailed description of the preferred embodiments of the invention, reference will now be made to the accompanying drawings, wherein:

Figure 1 is an elevational view, partially cutaway and partially in cross-section, showing the surge arrester and arrester housing of the present invention;

Figure 2 is a cross-sectional view of the arrester housing shown in Figure 1;

Figure 3 is a cross-sectional view of the housing shown in Figure 2 in its as-molded and unstretched configuration;

Figure 4 is an enlarged view of a portion of the as-molded and unstretched housing shown in Figure 3;

Figure 5 is a view similar to that shown in Figure 4 showing a cross-sectional view of a portion of the weathershed both before and after it has been stretched to accommodate and house the arrester components shown in Figure 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

It will be understood that the following components are representative of the contexts in which the present invention can be used and are not intended to be an exhaustive identification thereof. Referring first to Figure 1, surge arrester 10 and arrester housing 20 of the present invention are shown. Arrester 10 generally comprises hanger 12, top and bottom terminal studs 14, 16, ground lead disconnecter 18 and elastomeric housing 20. Arrester 10 is supported by arrester hanger 12 which, in turn, is mounted to a utility pole or other support member (not shown). Housing 20 encloses an array 22 of arrester components that are maintained in stacked end-to-end arrangement by an insulative component retention means 28. Retention means 28 may comprise, for example, an insulative liner such as that shown in U.S. Patent No. 4,930,039 or filament windings such as disclosed in U.S. Patent Nos. 5,138,517, 4,656,555 or 5,043,838. It is preferred, however, that insulative component retention means 28 be made in the form of a hardened resinous coating, reinforced with glass fibers, and having a coefficient of thermal expansion that is greater than the coefficient of thermal expansion of the electrical components in array 22 so as to provide an axial load on the components once cured and cooled. Such an embodiment is described in copending U.S. application entitled Self-Compressive Surge Arrester

Module and Method of Making Same, Serial No. 60/012,667, filed March 1, 1996, the entire disclosure of which is incorporated herein by this reference.

Array 22 includes electrodes 25, metal oxide varistors (MOV's) 26 and end terminals 24 at each end. Upper and lower conducting studs 14, 16 threadedly engage central threaded bores (not shown) in the ends of terminals 24 so as to provide a means for connecting line potential and ground lead conductors (not shown) to arrester 10. Conventional ground lead disconnect or isolator 18 is disposed about terminal stud 16 to provide a means to explosively disconnect the ground lead in the event of arrester failure. MOV's 26 are stacked within array 20 in end-to-end relationship with electrodes 25 disposed between facing surfaces of adjacent MOV's 26. MOV's 26 may be in the form of any conventionally available metal oxide varistor. Although not shown in Figure 1, array 22 may also include a variety of other electrical components, including heat sink or spacer elements or spark gap assemblies which may themselves include ceramic materials, such as silicon carbide rings having voltage dependent resistances.

Housing 20 is best shown in Figure 2. Housing 20, as shown, has particular utility when employed in a distribution class surge arrester. Although the principles of the present invention may be employed in surge arresters having other physical dimensions and ratings, the invention will be understood and will be described herein with reference to the 10KA heavy duty 10KV (8.4 KV MCOV) distribution class arrester shown in Figure 1.

Referring still to Figure 2, housing 20 generally comprises a sleeve having a central tubular core 30 and downwardly extending sheds 36 attached to core 30 in axially spaced apart relation. Housing 20 may therefore be described as a shedded sleeve. Core 30 includes central bore 31, inner cylindrical surface 32 and outer cylindrical surface 34. Sheds 36, which are integrally molded with core 30, extend from outer surface 34 and include an upper surface 38, lower surface 40 and outer edge 42. Upper and lower surfaces 38, 40 are generally frustoconical in shape although, as described more fully below with reference to Figure 5, surfaces 38 and 40 each include certain segments 61, 63 that are concave and other segments 62 that are convex. Sheds 36 extend radially outward from core 30 and preferably are inclined between approximately 10 and 60°, and more preferably between 20 and 45°, from a plane perpendicular to the central axis of housing 20. This angle of inclination indicates the angle of the greater top shed surface 55.

The inclined shed shape has several advantages. The inclined angle assures that a portion of the shed is protected from both contamination and wetting such that it maintains a high surface resistivity. The remaining surface can become contaminated with salts and dust and will have a much lower surface resistivity when wet, but the inclination will tend to wash much of the contamination off.

Still referring to Figure 2 in its as-used configuration, core 30 includes an inside diameter D_1 measured from opposite sides of inner cylindrical surface 32 and an overall outer diameter D_2 as measured from opposite shed ends 42 as shown in Figure 2. In this embodiment, D_1 is substantially equal to 1.7 inches and D_2 substantially equal to 3.6 inches. Housing 20 is molded from an elastomeric material to enable the housing to be stretched as described more fully below. Preferably, housing 20 is made of polymeric material, such as silicone rubber. To permit the stretching and deformation required, housing 20 should be made from a silicone rubber. While other elastomeric compounds can be used, silicone is preferred because of its natural resistance to UV radiation. Although other compounds can be formulated to resist UV degradation, some surface damage will still occur, increasing the risk of tear propagation from surface flaw sites. The advantage of using silicone to form the housing lies in the ability of silicone to repel water. When water full of contaminants beads up on the surface, the surface resistivity is much higher than if the water were present as a surface wetting film. Other materials have provided a hydrophobic quality when new, but lose this trait as they age. Suitable materials for housing 20 are those supplied by Dow Corning STI, General Electric Silicones, Wacker Silicones, DuPont, and Uniroyal, and having elongation at break per ASTM D412 higher than the stretched elongation levels and also exhibiting good physical and electrical performance for their operating environment per well known industry standards. The preferred polymer system is a highly filled silicone system containing Aluminum Trihydrate ("ATH") surface treated fumed silica and optional extending fillers such as silica flour. This system preferably has an elongation at break of greater than 300%, a durometer (shore A) of less than 50, and a Wet Arc Track performance of 180 minutes at 6 kV when the sample is tested at stretched level approximately 125% of the level in the application. An additional desirable criteria is for the failure mode after Wet Arc Track Testing to be nontracking in nature, *i.e.*, due to material erosion, and such that there is no evidence of tear propagation at the failure site. If these conditions are met, the housing will continue to withstand voltage and extend product life, even after a localized material failure has occurred.

Referring now to Figure 3, housing 20 is shown in its as-molded configuration, prior to it being stretched and deformed into its as-used configuration so as to accommodate MOV's 26 and the other arrester components of array 22. In this unstretched configuration, sheds 36 are axially spaced apart approximately 1.375 inches and core 30 has an inside diameter of D_1' and an outside diameter D_2' . In its unstretched configuration, D_1' is approximately 1.2 inches, or 60 to 90% of D_1 . Importantly, however, the outside diameter D_2' of the unstretched housing 20 is substantially the same as the overall diameter D_2 of housing 20 when stretched. To achieve the desired configuration of housing 20 as shown in Figure 2 when inside diameter D_1' is increased to D_1 , it is important that housing 20 and, particularly, sheds 36 be molded to have particular inclinations

and radii of curvature and degrees of taper. More specifically, and referring now to Figure 4, upper surface 38 of shed 36 joins outer surface 34 of core 30 at upper arcuate surface 46. The terms "upper" and "lower" are used hereinafter to refer to relative positions and orientations as shown in the figures. Upper arcuate surface 46 has a radius of curvature designated as R_1 which, in the embodiment shown is substantially equal to 0.375 inches. Similarly, lower surface 40 of shed 36 intersects core outer surface 34 at lower arcuate surface 48, which has a radius of curvature equal to R_2 . In this embodiment, R_2 is substantially equal to 0.093 inches. Without regard to the precise radii, to achieve the desired change in inclination and shape of weathersheds 36 from that shown in Figure 1 to that shown in Figure 2, R_1 should be greater than R_2 and is preferably at least twice as great as R_2 . In addition, the downward angle on the top side is preferably greater than or equal to the upward angle on the bottom side.

Referring still to Figure 4, upper and lower surfaces 38, 40 each include a pair of frustoconical segments having varying degrees of incline or decline as measured from a plane that is substantially perpendicular to the longitudinal axis of housing 20. These frustoconical segments are best described with reference to transition points 51-54. As molded, shed 36 includes an upper surface comprising first and second upper frustoconical segments 55, 56 and a lower surface 39 comprising first and second lower frustoconical segments 57, 58. First upper frustoconical surface segment 55 extends between transition point 51 and transition point 52 and slopes downwardly at an incline from horizontal equal to α_1 . Second upper frustoconical surface segment 56 extends from transition point 52 to shoulder 59 adjacent outer edge 42, and tapers downwardly at an angle from horizontal equal to α_2 . First lower frustoconical surface segment 57 extends between transition points 53 and 54 and inclines upwardly from the horizontal at an angle equal to α_3 . Second lower frustoconical surface segment 58 extends between transition point 54 and outer edge 42 and is inclined upward from the horizontal at an angle equal to α_4 . α_1 - α_4 will vary depending upon the size of housing 20 and the precise operational orientation desired of sheds 36, however, for the embodiment shown in Figure 1, for example, α_1 - α_4 will have the following values.

<u>Angle</u>	<u>Degrees</u>
α_1	10°
α_2	1°
α_3	0.5°
α_4	0.5°

Without regard to the precise values of α_1 - α_4 , according to the invention, transition point 51 should be at a greater radius from the axis 21 of housing 20 than transition point 53, and transition point 52 should be at a greater radius than transition point 54. In the specific embodiment described herein, transition point 52 is located at a radial distance substantially equal

to 1.467 inches, while transition point 54 is located at a radial distance substantially equal to 1.342 inches. Also in this embodiment, transition point 51 is located at a radial distance substantially equal to .37 inches and transition point 53 is located at a radial distance substantially equal to .09 inches.

5 In some instances (not shown), it may be preferred to use only a single frustoconical section for lower surface 40. This surface extends from a single transition point, with that single transition point being between the two transition points 51, 52 on upper surface 38.

10 In its unstretched configuration as shown in Figures 3 and 4, housing core 30 has a wall thickness of substantially 0.109 inches and outer edge 42 is approximately 1.090 inches from outer surface 34 of core 30 so that D_2' equals approximately 3.614 inches. D_1' is substantially equal to 1.216 inches.

15 Upon assembly of arrester 10, MOV's 26 and terminals 24 are secured into a subassembly by retention means 28. To install the subassembly within housing 20, a blunt, conical shaped nose cone (not shown) is placed atop a terminal 24. The nose cone includes a base portion substantially the same diameter as terminal 24 and a conical or tapered end spaced apart from the base end and extending away from array 22. The tapered end of the nose cone has a terminus that is smaller in diameter than D_1' . One end of unstretched housing 20 (shown in Figure 3) is disposed about the tapered end of the nose cone and housing 20 is then drawn over array 22. As housing 20 is drawn over the array 22, it is stretched so as to accommodate array 22 and assumes the configuration shown in Figure 2. When stretched to accommodate array 22, housing 20 shrinks in length about 8% as compared to its length before it is radially stretched to accommodate array 22. Once the housing 20 is stretched about the arrester components, the remaining steps in the assembly process of arrester 20 are performed in the following order.

20 The arrester module is primed with a low viscosity neutral cure silicone RTV. The primer cure is accelerated at a temperature of between 100 and 200°C. Before the housing is applied, a lubricating film of neutral cure RTV is applied, which bonds the housing to the arrester module. The RTV can be cured at an accelerating temperature, although this not necessary. The remaining assembly steps are comparable to those known in the art of surge arresters.

25 Referring now to Figure 5, shed 36 is shown in profile both in the as-molded, unstretched configuration, referred to generally by reference numeral 66, and its post-stretched configuration 68. As previously noted, the ends 42 of shed 36 remains in substantially the same radial position with reference to housing axis 21 even though the inner and outer surfaces 32, 34 of core 30 are moved radially outward substantial distances. In the stretched configuration 68, upper surface 38 generally comprises three interconnected curved surfaces 61-63, curved surface 61 and 63 being generally concave while curved surface 62, which is intermediate between surfaces 61 and 63, is

generally convex. The stretched configuration is a function of relative volumes of the unstretched upper and lower portions of each shed.

The present shedded elastomeric housing provides superior performance and costs less to manufacture than many previously known housings. Cost savings are realized because the perpendicular sheds of the present invention are much easier to demold during the manufacturing process. The ease of demolding allows the sheds on the present housing to be significantly thinner, requiring the use of less material. Quality is also improved both in the housing itself and its performance. Housing quality is improved because the simpler molded shape results in a lower defect rate in molded parts.

Performance is improved because the elastomeric housing can conform to irregularities in the array, particularly if it is used in conjunction with a silane surface treatment and/or a silicone RTV material. The silane surface treatment and/or silicone RTV material acts to bond the present housing to the array so as to prevent the ingress of moisture therebetween and also functions as a lubricant and void-filling compound during the insertion of the arrester module. The present method is advantageous over conventional methods of molding a housing over an array, as this molding process requires lower viscosity, less desirable silicones compounds so as to avoid shifting of the array due to high forces that are imposed during molding. Other suitable bonding agents include silane primers, silicone grease, silicone spray, and similar substances, but it is preferred to use substances that provide a bonded interface.

Ability to perform under operating conditions is affected by the quality of the interface between the housing and the array. A good measure of performance can be made using MultiStress techniques commonly applied on polymeric insulators and arresters, such as the Italian National utility (ENEL) procedure DY1009 or the IEC procedure IEC1109 (1992). Adequate performance per the ENEL procedure has been achieved due solely to the pressure exerted on the interface due to the level of stretch, provided that the interface is substantially air free or that air pockets are large enough and controllable positioned so as to avoid creating unacceptable high localized dielectric stresses. The degree of flexibility of the housing depends on the material selected and on the anticipated voltage level. Adequate performance has been demonstrated on an arrestor product having an air-filled open-weave fiberglass cage similar to that described in U.S. Patent No. 5,043,838. Good performance has also been demonstrated on arrester products using a silicone grease substantially air displacing interface on arresters constructed as described in U.S. Patent No. 4,656,555 and the copending application mentioned above. The best performance has been achieved using a substantially bonded interface and the arrester module construction as described in our copending application. Adequate bonding has been achieved using a neutral cure RTV silicone compound at the interface between the housing and the array. As discussed above, this

material also lubricates the housing during placement of the housing over the array. Further improvements have been noted when the resin coated modules have been primed with either a silane-based primer or a spray-on, cured RTV coating similar to those commonly used to coat high voltage ceramic insulators.

5 While preferred embodiments of the invention have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of the invention. The embodiments described herein are exemplary only, and are not limiting. Many variations and modifications of the invention and apparatus disclosed herein are possible and are within the scope of the invention. Accordingly, the scope of protection is not
10 limited by the description set out above, but is only limited by the claims which follow, that scope including all equivalents of the subject matter of the claims.

CLAIMS

What is claimed is:

1. An elastomeric housing for electrical apparatus, comprising:

a deformable shedded sleeve having a central axis and comprising a tubular core portion with a central bore and a plurality of axially-spaced sheds extending from said core; wherein said sleeve has a first configuration when said core is unstretched and a second configuration when said core is stretched; and

wherein said sheds extend from said core at a first angle relative to said axis when said sleeve is in said first configuration and extend from said core at a second angle relative to said axis when said sleeve is in said second configuration.

2. The elastomeric housing according to claim 1 wherein when said sleeve is in said configuration, said sheds extend downwardly from said core at an angle within the range of approximately 10 to 45° as measured from a plane that is perpendicular to said axis.

3. The housing of claim 2 wherein said sheds extend substantially perpendicularly from said core when said sleeve is in said first configuration and wherein said sleeve assumes said second configuration when said core is stretched radially outwardly.

4. The housing of claim 2 wherein when said sleeve is in said first configuration, said sheds include an upper surface that joins said core in a first shoulder having a radius of curvature R_1 and a lower surface that joins said core in a second shoulder having a radius of curvature R_2 and wherein R_1 is greater than R_2 .

5. The housing according to claim 4 wherein R_1 is at least twice as large as R_2 when said sleeve is in said first configuration.

6. The housing according to claim 2 wherein said sleeve has substantially the same overall diameter in said first and said second configurations.

7. The housing according to claim 6 wherein in said first configuration, said central bore has a diameter equal to D_1 and wherein in said second configuration said bore has a diameter equal to D_2 , where D_2 is greater than D_1 .

8. The housing according to claim 2 wherein said sheds include a first end disposed at a predetermined radial position relative to said axis and a second end attached to said core portion, and wherein when said sleeve is in said second configuration, said sheds include a generally frustoconical upper surface and a convex portion on said upper surface between said first and said second ends.

9. The housing according to claim 1 wherein said sheds include an ends disposed at predetermined radial and axial positions when said sleeve is in said first configuration and wherein when said shed is deformed to said second configuration, said shed ends are disposed in axial

direction away from said first predetermined position but remain at said first predetermined radial position.

10. A housing for electrical apparatus, comprising:

an elastomeric sleeve having a tubular core portion with a central axis and a central bore and having a plurality of sheds radiating from said core portion;

wherein said sheds have ends disposed a predetermined radial distance from said axis; and

wherein said sheds include an upper surface comprising a first frustoconical surface segment joined to said core portion in an upper shoulder having a radius of curvature R_1 and a second frustoconical surface segment joined to said first frustoconical surface segment at a first transition point T_1 ; and

wherein said sheds include a lower surface comprising a third frustoconical surface segments joined to said core portion in a lower shoulder having a radius of curvature R_2 that is less than R_1 and fourth frustoconical surface segment joined to said third frustoconical surface segment at a second transition point T_2 that is radially closer to said axis than T_1 .

11. The housing according to claim 10 wherein said first frustoconical surface segment tapers downwardly from said upper shoulder to said first transition point at an angle α_1 and wherein said second frustoconical surface segment tapers downwardly from said first transition point toward said end of said shed at an angle α_2 , wherein α_2 is less than α_1 .

12. The housing according to claim 11 wherein said third frustoconical surface segment tapers upwardly from said lower shoulder to said second transition point at an angle α_3 and wherein said fourth frustoconical surface segment tapers upwardly from said second transition point to said end of said shed at an angle α_4 that is less than α_3 .

13. The housing according to claim 12 wherein α_1 is at least twice as great as a α_2 .

14. The housing according to claim 12 wherein α_1 is at least four times as great as α_2 .

15. The housing according to claim 12 wherein α_3 is substantially equal to α_4 .

16. The housing according to claim 12 wherein α_2 is at least twice as large as α_4 .

17. The housing according to claim 12 wherein first frustoconical surface segment intersects said upper shoulder at a third transition point and said third frustoconical surface segment intersects said lower shoulder at a fourth transition point, and wherein said fourth transition point is radially closer to said axis than said third transition point.

18. The housing according to claim 12 wherein R_1 is at least twice as large as R_2 .

19. The housing according to claim 10 wherein said sleeve is deformable from a first configuration when said core is unstretched to a second configuration when said core is stretched

radially outwardly, said ends of said sheds being lower when said sleeve is in said second configuration compared to first configuration.

20. The housing according to claim 19 wherein when said sleeve is in said second configuration, said ends of said sheds remain at said predetermined radial distance from said axis.

5 21. An elastomeric housing for electrical apparatus, comprising:

a deformable shedded sleeve having a central axis and comprising a tubular core with a central bore having an inside diameter and a plurality of axially-spaced sheds having upper and lower surfaces and radiating from said core in a first configuration;

10 said sleeves being configured such that stretching of said core so as to increase said inside diameter causes said sheds to deform into a second configuration in which said sheds assume a downwardly extending position and said upper surface of said shed is generally frustoconical.

22. The elastomeric housing according to claim 21 wherein in said first configuration each shed is substantially perpendicular to said axis.

15 23. The elastomeric housing according to claim 21 wherein when said sleeve is in said first configuration, each of said upper and lower surfaces includes at least one frustoconical portion.

24. The elastomeric housing according to claim 23 wherein when said sleeve is in said first configuration, said first frustoconical portion intersects a plane perpendicular to said axis at an angle of approximately 2.5° .

20 25. The elastomeric housing according to claim 23 wherein each of said upper and lower surfaces includes two concentric frustoconical portions.

26. The elastomeric housing according to claim 25 wherein when said sleeve is in its first configuration, said second frustoconical portion intersects a plane perpendicular to said axis at an angle of less than approximately 2.5° .

25 27. The elastomeric housing according to claim 21 wherein when said sleeve is in said first configuration, said upper surface intersects said core at a first shoulder having a radius of curvature R_1 , and said lower surface intersects said core at a lower shoulder having a radius equal to R_2 , and wherein R_1 is greater than R_2 .

28. The elastomeric housing according to claim 27 wherein R_1 is at least $2 \times R_2$.

30 29. The elastomeric housing according to claim 28 wherein each of said upper and lower surfaces includes a first frustoconical portion, said upper first frustoconical portion intersecting said first shoulder at a first upper transition point and said lower first frustoconical portion intersecting said second shoulder at a first lower transition point, said first upper transition point being at a greater radial distance from said axis than said first lower transition point.

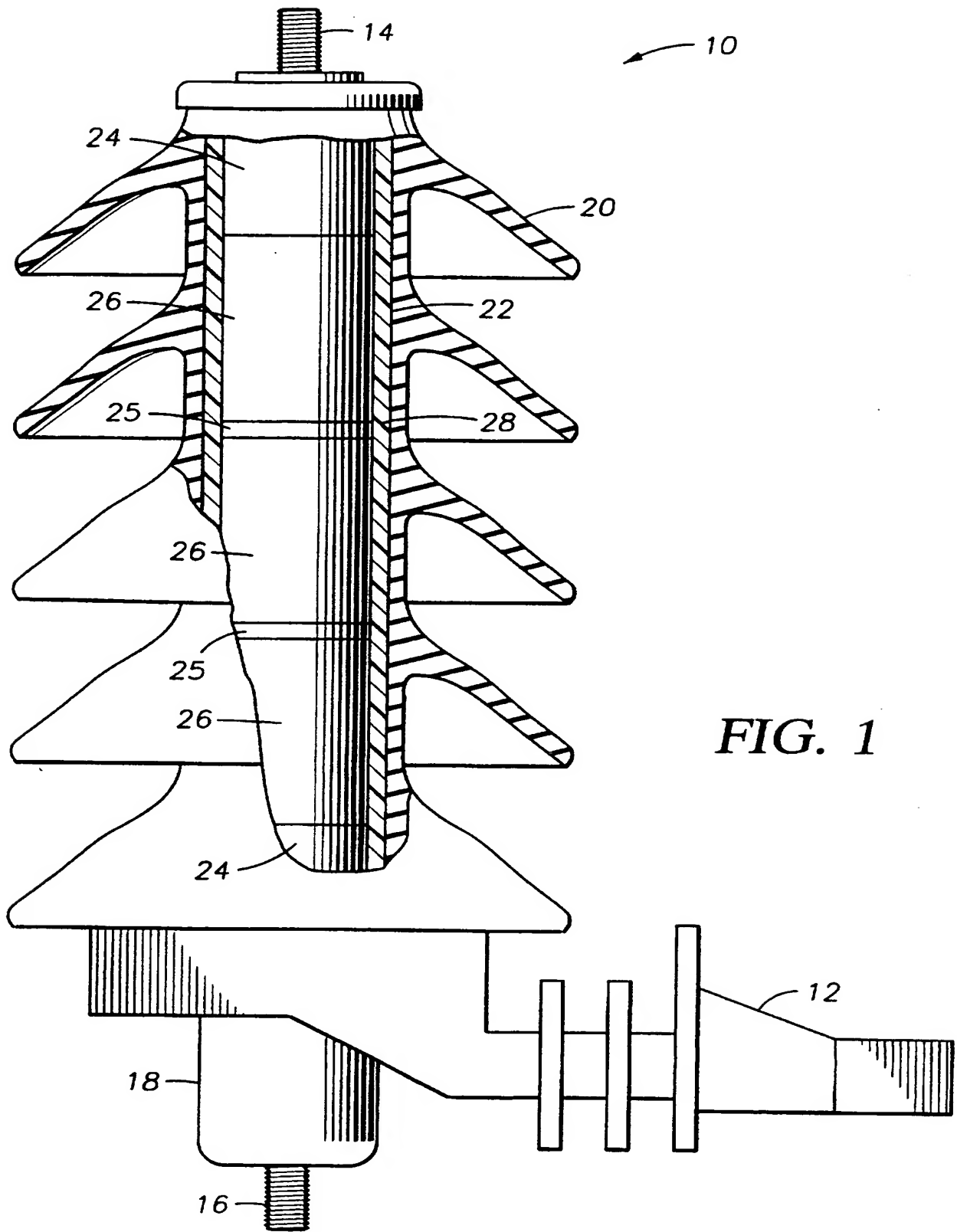
5 30. The elastomeric housing according to claim 29 wherein each of said upper and lower surfaces further includes a second frustoconical portion, said upper second frustoconical portion intersecting said upper first frustoconical portion at a second upper transition point and said lower second frustoconical portion intersecting said lower first frustoconical portion at a second lower transition point, said second upper transition point being at a greater radial distance from said axis than said second lower transition point.

10 31. The elastomeric housing according to claim 21 wherein each shed has an upper surface and a lower surface, and wherein when said sleeve is in said second configuration, said upper surface includes first and second circumferentially concave portions and a first circumferentially convex portion therebetween.

32. The elastomeric housing according to claim 21 wherein said sheds comprise radially extending members having outer edges, said radially extending members decreasing in thickness toward their outer edges.

15 33. The elastomeric housing according to claim 32 wherein in both said first and second configurations, said outer edges of said sheds remain at substantially the same radial position relative to said axis.

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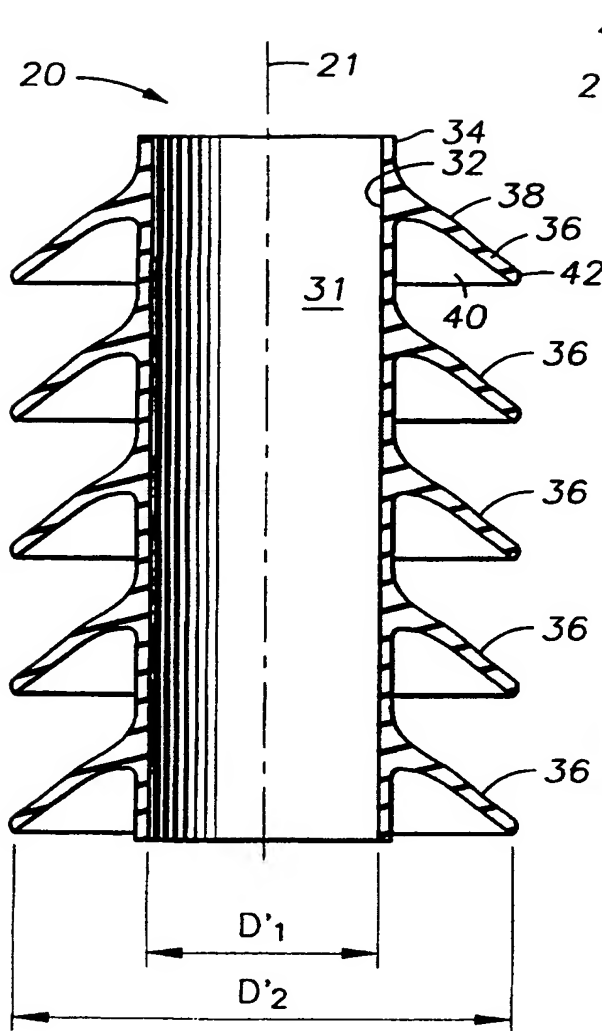


FIG. 2

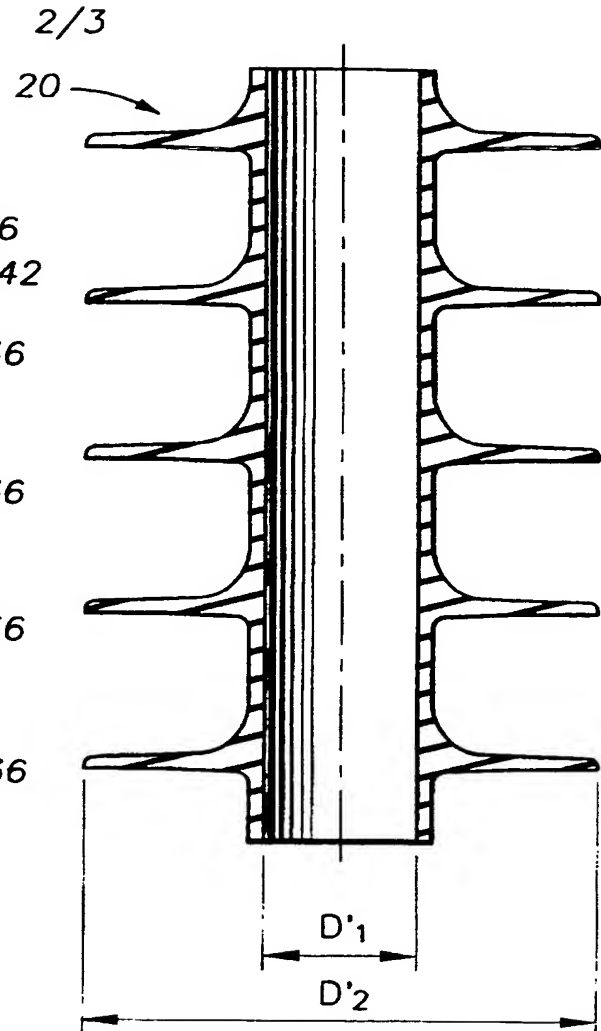


FIG. 3

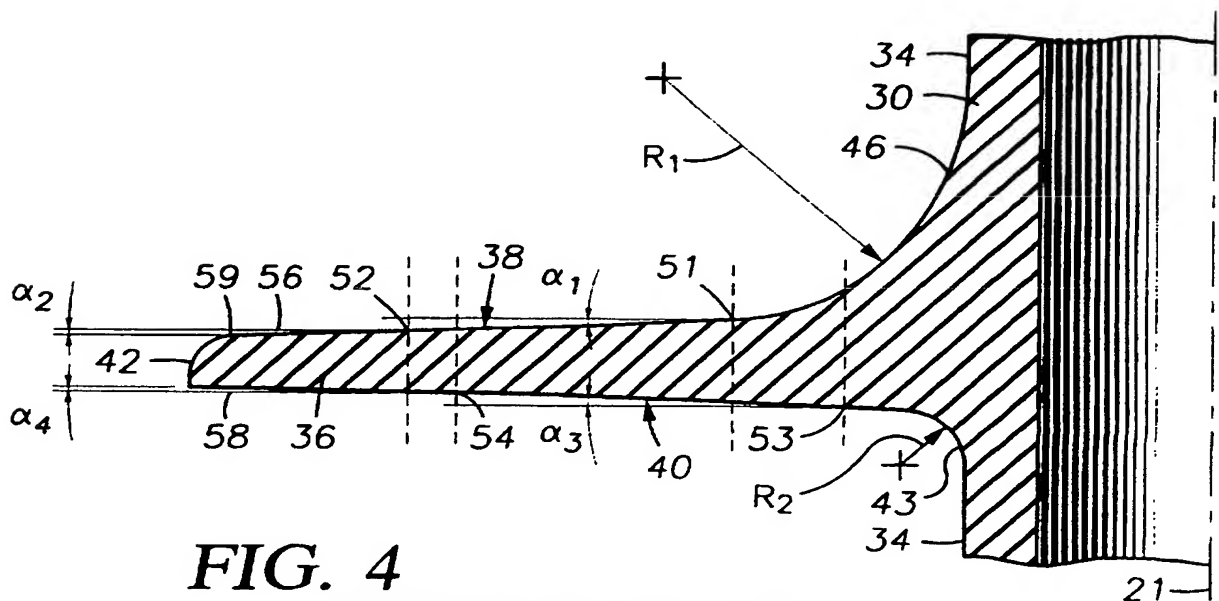
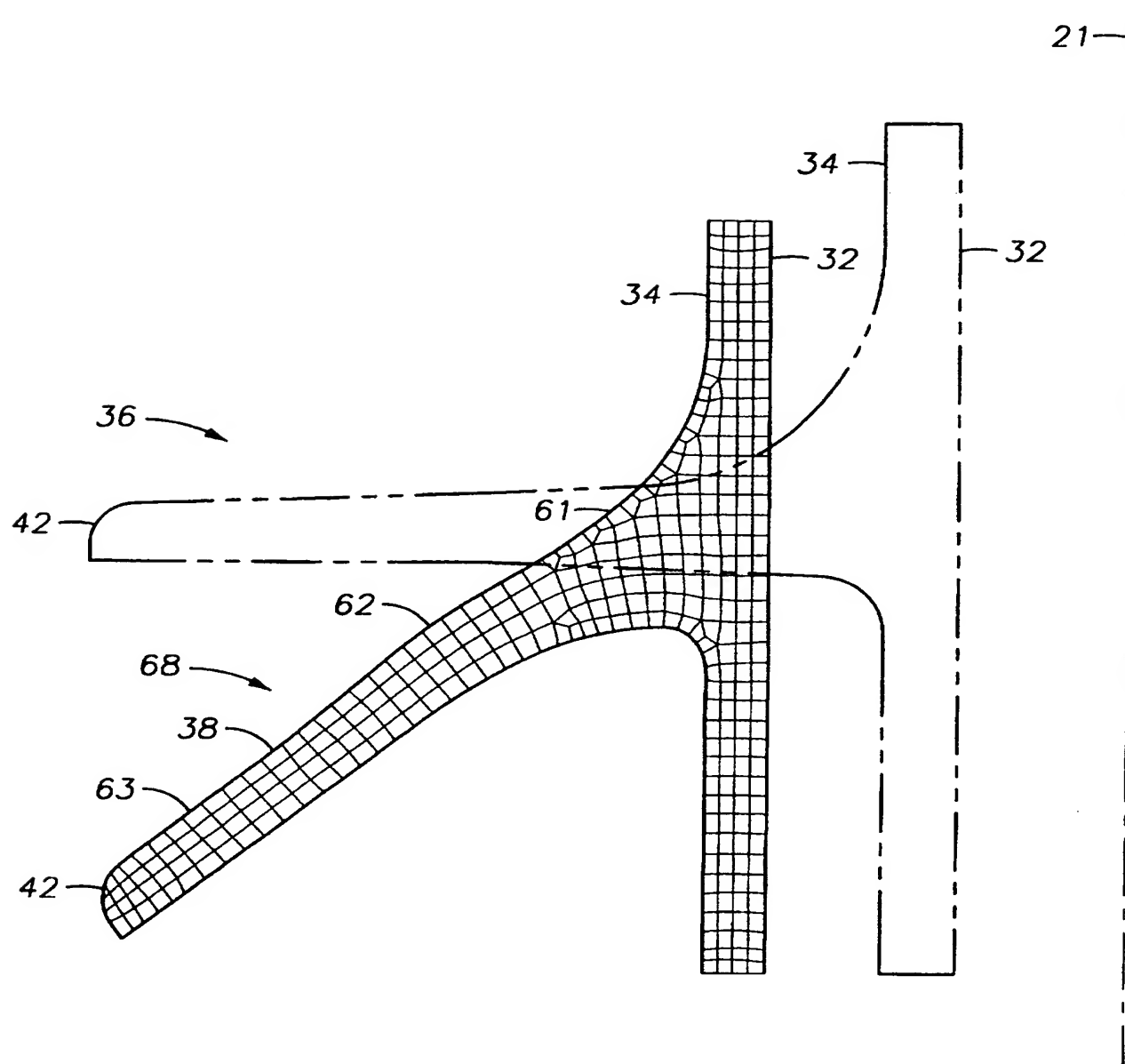


FIG. 4

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**FIG. 5**

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/02967

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H01B 17/32

US CL :Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,885,039 A (THEVENET) 05 December 1989, the figure.	1-9, 21-24, 27-28, 32-33
X	US 5,220,134 A (NOVEL et al) 15 June 1993, figure 5.	1-9, 21-24, 27-28, 32-33
A	US 4,028,656 A (SCHMUNK et al) 07 June 1977, see entire document.	1-33

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

09 MAY 1997

Date of mailing of the international search report

09 JUL 1997

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/02967

A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

174/209, 211

B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

174/209, 211, 142, 176, 177, 178, 179, 189, 196, 209, 212, 174, DIG10, 137R, 138R, 139

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